ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

Radiation in the Environment

Sources of Radiation

Members of the public are routinely exposed to ionizing radiation from both natural and man-made sources. An individual living in the United States (U.S.) is estimated to receive an average annual effective dose equivalent of about 360 millirem (mrem) (3.6 millisieverts [mSv]) (National Council on Radiation Protection and Measurements Report 93 [1987b]).

While most of the radiation dose received by the general public is from natural background sources, man-made sources of radiation also contribute to the average dose. Such sources include diagnostic and therapeutic x-rays, nuclear medicine, fallout residues from atmospheric nuclear weapons tests, effluents from nuclear fuel-cycle facilities, and consumer products such as smoke detectors and cigarettes (Fig. 2-1).

Routine activities at the West Valley Demonstration Project (WVDP or Project) have the potential to release radioactive or hazardous substances that could affect the environment.

Exposure Pathways

The radionuclides present at the WVDP site are residues from the reprocessing of commercial nuclear fuel during the 1960s and early 1970s by a previous site operator. A very small fraction of these radionuclides is released off site during the year through ventilation systems and liquid discharges. These releases make a negligible contribution to the radiation dose to the surrounding population through several exposure pathways.

An exposure pathway consists of a route for a source of contamination or radiation to be transported by environmental media to a receptor where exposure may occur. For example, a member of the public could be exposed to low concentrations of radioactive particles carried by prevailing winds.

The potential pathways of exposure from Project emissions are inhalation of gases and particulates, ingestion of locally grown food products, consumption of fish, beef, and venison, and exposure to external penetrating radiation emitted from contaminated materials. Table 2-1 summarizes the potential exposure pathways for the local off-site population and describes the rationale for includ-

Ionizing Radiation

Radiation can be damaging if, in colliding with other matter, the alpha or beta particles or gamma rays knock electrons loose from the absorber atoms. This process is called ionization, and the radiation that produces it is referred to as ionizing radiation. Ionization changes an electrically neutral atom, in which the positively charged protons and the negatively charged electrons balance each other, into a charged atom called an ion. An ion can be either positively or negatively charged. Various kinds of ionizing radiation produce different degrees of damage.

Potential Effects of Radiation

Biological effects of radiation can be either somatic or genetic. Somatic effects of radiation exposure are limited to the exposed individual. For example, sufficiently high exposure to radiation can cause clouding of the lens of the eye or a decrease in white blood cells.

Radiation can also cause chromosomes to break or rearrange themselves or to join incorrectly with other chromosomes. These changes may produce genetic effects and may show up in future generations. Radiation-produced genetic defects and mutations in the offspring of an exposed parent, while not positively identified in humans, have been observed in some animal studies.

The effect of radiation depends on the amount absorbed within a given exposure time. The only observable effect of an instantaneous whole-body dose of 50 rem (0.5 Sv) might be a temporary reduction in white blood cell count. An instantaneous dose of 100–200 rem (1–2 Sv) might cause additional temporary effects, such as vomiting, but usually would have no long-lasting side effects. Assessing biological damage from low-level radiation is difficult because other factors can cause the same symptoms as radiation exposure. Moreover, the body is able to repair damage caused by low-level radiation. There have been no documented effects from exposures of less than 10 rem.

The effect most often associated with exposure to relatively high levels of radiation appears to be an increased risk of cancer. However, scientists have not been able to demonstrate with certainty that exposure to low-level radiation causes an increase in injurious biological effects, nor have they been able to determine if there is a level of radiation exposure below which there are no adverse biological effects.

Health Effects of Low-Level Radiation

Radionuclides entering the body through air, water, or food are distributed in different organs of the body. For example, isotopes of iodine concentrate in the thyroid. Strontium, plutonium, and americium isotopes concentrate in the skeleton. When inhaled, particulate uranium and plutonium isotopes may remain in the lungs for a long period of time. Some radionuclides such as tritium, carbon-14, or cesium-137 are distributed uniformly throughout the body. Thus, depending on the radionuclide, some organs may receive quite different doses. Moreover, at the same dose levels, certain organs (such as the breast) are more prone to developing a fatal cancer than other organs (such as the thyroid).

Because of the uncertainty and difficulty in measuring the incidence of increased cancer resulting from exposure to ionizing radiation, to be conservative, a linear model is used to predict health risks from low levels of radiation. This model assumes that there is a risk associated with all dose levels even though the body may effectively repair damage incurred from low levels of alpha, beta, and gamma radiations.

ing or excluding each pathway when calculating dose from the WVDP. For instance, drinking water is not considered a pathway for exposure from the WVDP because surveys revealed that local residents do not use Cattaraugus Creek as a source of drinking water.

Land Use Survey

Periodic surveys of local residents provide information about local family sizes, sources of food, and gardening practices. In early 2003, census information from calendar year (CY) 2000 was used to update population files used for dose assessment. Information from the most recent land use survey, conducted in early 2002, was used to confirm the locations of the nearest residences. These parameters are required for computer models that are used for the annual dose assessments. (See the discussion of Dose Assessment Methodology later in this chapter for more information on calculation of dose to the public.)

Dose to the Public

Each year the potential radiological dose to the public that is attributable to operations and effluents from the WVDP is assessed to verify that no individual could credibly have received a dose exceeding the limits established by the regulatory agencies.

Estimated doses are compared directly with current radiation standards established by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) for protection of the public. These values are also compared with the annual dose an average U.S. resident receives from natural background radiation and to doses reported in previous years for the Project. Figure 2-1 shows the relative contribution to the annual dose in mrem from natural and man-made sources in comparison with the estimated CY 2004 maximum individual dose from the WVDP. (Units of dose measurement are explained in detail later in this chapter.)

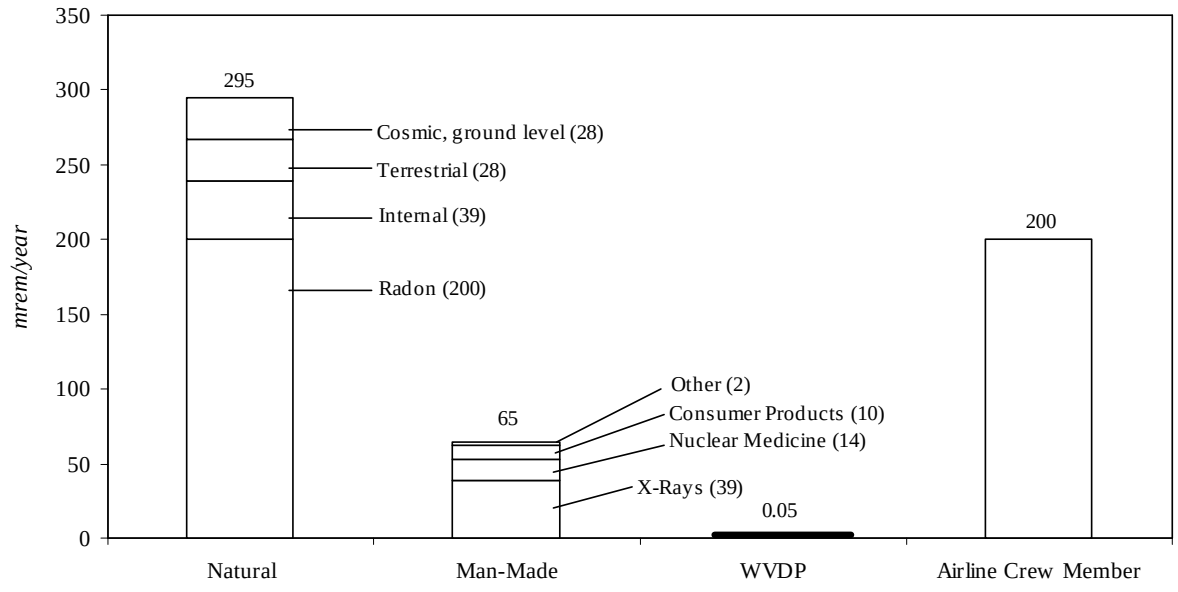


Figure 2-1. Comparison of Doses From Natural and Man-Made Sources to the Dose From 2004 WVDP Effluents

As can be seen in Figure 2-1, natural sources of radiation contribute 295 mrem (2.95 mSv) and man-made sources contribute 65 mrem (0.65 mSv) of the total annual U.S. average dose of 360 mrem (3.60 mSv). In 2004, the WVDP contributed a very small amount (0.049 mrem [0.00049 mSv]) of the total annual man-made radiation dose to the maximally exposed off-site individual (MEOSI) residing near the WVDP. This is much less than the average dose received from using consumer products and is insignificant compared to the federal standard of 100 mrem allowed from any DOE site operations in a calendar year and the 295 mrem received annually from natural sources. The dose from WVDP operations also is small compared to the estimated average additional dose an airline crew member typically receives from cosmic radiation (200–900 mrem/year).

The results of these conservative dose calculations demonstrate that the potential maximum dose to an off-site resident is well below permissible standards and is consistent with the as-low-as-reasonably-achievable philosophy of radiation protection.

The following sections describe the monitoring program used to measure radiation in the environment near the WVDP and the methods used and results of dose assessments using these measurements.

Table 2-1
Potential Local Off-Site Exposure Pathways Under Existing WVDP Conditions

Exposure Pathway and Transporting Medium	Reason for Inclusion/Exclusion
Inhalation: gases and particulates in air (included)	Off-site transport of contaminants from WVDP stacks or resuspended particulates from soils or water
Ingestion: cultivated crops (included)	Local agricultural products irrigated with potentially contaminated surface or groundwater; foliar deposition and uptake of deposited airborne contaminants
Ingestion: surface and groundwater (excluded)	No documented use of local surface water or downgradient groundwater wells as drinking water by local residents
Ingestion: fish, beef, venison, and milk (included)	Fish exposed to contaminants in water or sediments may be consumed; beef, venison, and milk consumption following deposition of transported airborne and surface water contaminants
External exposure: radiation from particulates and gases directly from air or surface water or indirectly from surface deposition (included)	Transport of air particulates and gases to off-site receptors; transport of contaminants in surface water and direct exposure during stream use and swimming

Release of Materials Containing Residual Radioactivity. The release of property containing residual radioactivity from DOE facilities is carefully controlled by DOE guidelines and procedures. In two special memoranda issued in January and July of 2000, the Secretary of Energy placed a moratorium on release of contaminated materials and on unrestricted release, for metal recycling from radiological areas within DOE facilities. The moratorium will remain in effect until directives clarifying the release criteria have been developed and implemented. Any transfer that places property (real property, structures, equipment, or scrap metal) containing radioactivity into public use is classified as a type of environmental release.

In keeping with DOE initiatives to expand environmental information provided to the public, certain details of transfers of property containing residual radioactivity are to be included in Annual Site Environmental Reports. The information provided should include, among other things, the type of material and amount of residual radioactivity, the basis for releasing the property for public use (including release limits and when the property was released), the end use and cost savings associated with release of the property, and potential doses to individuals and potential collective dose to the public associated with each release. As indicated in Table 2-2, the WVDP did not release any property classified per DOE Order 5400.5 as material containing residual radioactivity in 2004.

Table 2-2
Release of Property Containing Residual Radioactive Material

Approved Limit	Rationale	Date of Approval	Type of Material	Basis for Release	End Use	Volume of Material	Total Activity	Maximum Individual Dose	Collective Dose
NA	*NA*	*NA*	*None*	*NA*	*NA*	*0*	*0*	*0*	*0*

No property containing residual radioactivity was released in 2004.

Routine Monitoring Program

Radiological Sampling Program Overview

Samples from environmental media listed in Table 2-1 are collected each year and measured for radioactivity. Environmental sampling locations are shown on maps in Appendix A and the complete environmental monitoring schedule is summarized in Appendix B[CD]. This schedule provides information on monitoring and reporting requirements and the types and extent of sampling and monitoring at each location. An explanation of the codes that identify the sample medium and the specific sampling or monitoring location is also found in Appendix B[CD]. For example, a sample location code such as AFGRVAL indicates an air sample (A), collected off-site (F), at the Great Valley (GRVAL) sampling station. These codes are used throughout this report for ease of reference and to be consistent with the data reported in the appendices.

The food pathway is monitored by collecting samples of beef, milk, and produce at near-site and remote locations, samples of fish upstream and downstream of the site, and samples of venison from deer from near-site and background locations. Stream sediments are sampled upstream and downstream of the WVDP, and both on-site groundwater and off-site drinking water are routinely sampled. Direct radiation is monitored on site, at the perimeter of the site, in communities near the site, and at background locations.

The primary focus of the monitoring program, however, is on surface water and air pathways, as these are the principal means of transport of radionuclides from the WVDP.

Liquid and air effluents are monitored on site by collecting samples at locations where radioactivity or other regulated substances are released or might be released. Release points include water effluent outfalls and plant ventilation stacks.

Surface water samples are collected within the Project area from ponds, swamps, seeps, and drainage channels that flow through the Western New York Nuclear Service Center (WNYNSC) and then off site into Cattaraugus Creek.

Both surface water and air samples are collected at perimeter locations where the highest off-site concentrations of transported radionuclides might be expected. Samples are also collected at remote locations to provide background concentration data for comparison with data from on-site and near-site samples.

Overview of Water Effluent and Ambient Surface Water Monitoring

The Project is drained by several small streams. Frank's Creek flows along and receives drainage from the south plateau. As Frank's Creek flows northward, it is joined by a tributary, Erdman Brook, which receives effluent from the low-level waste treatment facility (LLWTF). On the north plateau, beyond the Project fence line, the north and northeast swamp areas and Quarry Creek drain into Frank's Creek. Frank's Creek continues across the WNYNSC and flows into Buttermilk Creek, which leaves the WNYNSC and enters Cattaraugus Creek (Figs. A-2 and A-3).

Liquid effluents from three locations (the LLWTF and the two natural drainages from the northeast

and north swamps) are primary contributors to site dose estimates. (See Predicted Dose From Waterborne Releases later in this chapter for an estimate of the dose attributable to these waterborne effluents.)

Low-Level Waste Treatment Facility Effluent. The discharge from the LLWTF through the lagoon 3 weir (WNSP001 on Fig. A-2) into Erdman Brook is the largest single source of radioactivity released to surface waters from the Project. There were eight batch releases totaling about 15.0 million gallons (56.6 million liters) in 2004.

The total amounts of radioactivity from specific radionuclides in the lagoon 3 effluent are listed in Appendix C-2CD. The annual average concentration of each radionuclide is divided by its corresponding DOE derived concentration guide (DCG) to determine what percentage of the DCG was released. (DCGs are discussed in Chapter 1. DOE DCGs for radionuclides of interest at the WVDP are listed in Appendix KCD.) As a DOE policy, the sum of the percentages calculated for all radionuclides released should not exceed 100%. The combined annual average of radionuclide concentrations from lagoon 3 effluent in 2004 was approximately 21.2% of the DCGs.

The LLWTF was designed to efficiently remove strontium-90 and cesium-137, the more prevalent of the long-lived fission products in WVDP wastewaters. Other radionuclides, such as uranium isotopes, are also removed to a lesser extent. Uranium isotopes are found in WVDP liquid waste because they were present in the nuclear fuel that was once reprocessed at the site. Uranium-232, a major contributor to the combined DCG in lagoon 3 effluent, averaged about 8% of its DCG in 2004. Variations in liquid effluent radionuclide ratios continue to reflect the dynamic nature of the waste streams being processed through the LLWTF.

Outfall WNSP001 and other selected discharge points are also monitored for nonradiological parameters under the New York State Pollutant Discharge Elimination System program. See Chapter 3, Environmental Nonradiological Program Information.

Northeast Swamp and North Swamp Drainage. These two drainages conduct surface water and emergent groundwater off site. The northeast swamp sampling location (WNSWAMP) is used to monitor surface water drainage from the northeastern portion of the site's north plateau. The north swamp sampling point (WNSW74A) is used to monitor drainage to Quarry Creek from the northern portion of the plateau (Fig. A-2).

Data summaries from these two locations are found in Appendix C-3CD. Elevated gross beta concentrations at WNSWAMP, first noted in 1993, continued to be observed in 2004. Gross beta activity at this location is largely attributable to strontium-90. Concentrations of all radioisotopic parameters detected at the two locations, other than strontium-90 at WNSWAMP, were less than 1% of the respective DCGs for these parameters.

Strontium-90 concentrations at WNSWAMP in 2004 averaged 1.31E-06 microcuries per milliliter (µCi/mL) (48.5 Becquerels per liter [Bq/L]), higher than the average result in 2003. (See Chapter 4 for a graph of annualized average strontium-90 concentrations at WNSWAMP in 2004.) Even though waters with elevated strontium-90 concentrations drain from WNSWAMP into Frank's Creek, concentrations in waters collected from Cattaraugus Creek downstream at the first point of access by the general public (WFFELBR) were only slightly higher than those at background location WFBIGBR, upstream of the location where site drainage enters Cattaraugus Creek.

Other North Plateau Surface Waters and Water Effluent. Discharges from WNSP001 and WNSP007 leave the site through point WNSP006. Radiological results of analyses from WNSP006 and WNSP007 are summarized in Appendices C-4 and C-2, respectively.

WNSP006. WNSP006 is located more than 2.5 miles (4.0 km) upstream from Thomas Corners Road, the last monitoring point before Buttermilk Creek leaves the WNYNSC and before the public has access to the creek waters. Many of the constituents detected in effluent from WNSP001 were not detectable a short distance downstream at location WNSP006. Radionuclides that were detected were found at concentrations at small percentages of the respective DCGs. The highest strontium-90 concentration at WNSP006 in 2004 was 3.52E-08 µCi/mL (1.30 Bq/L), which is less than 4% of its DCG (1E-06 µCi/mL).

Average concentrations for the radiological parameters detected at WNSP007 in 2004 were also at small percentages of their respective DCGs.

WNSP005 and WNCOOLW. Sampling point WNSP005 monitors overland drainage and groundwater seepage on the east side of the main plant and WNCOOLW monitors coolant water from a contained basin within the facility. Summaries of radiological data for WNSP005 and WNCOOLW are found in Appendix C-3.

Although most radiological concentrations for both locations were below detection levels in 2004, gross beta and strontium-90 were detected at WNSP005. The gross beta and strontium-90 levels at WNSP005 may be influenced by inactive Lagoon 1. (See Chapter 4, "Long-Term Trends of Gross Beta and Tritium at Selected Groundwater Monitoring Locations.") Although elevated with respect to background, gross beta and strontium-90 concentrations at WNSP005 were well below the strontium-90 DCG.

South Plateau Surface Water and Nuclear Regulatory Commission (NRC)-Licensed Disposal Area (NDA) Interceptor Trench. Two inactive underground radioactive waste disposal areas, the NDA and the New York State-Licensed Disposal Area (SDA), lie on the south plateau of the site. (The SDA is managed by the New York State Energy Research and Development Authority [NYSERDA].) The drum cell, an aboveground structure used to store approximately 20,000 drums of processed low-level radioactive waste, is located nearby. Surface waters, which flow from the south to the north, are routinely monitored at several points around these areas (Fig. A-2). In addition to routine samples collected by the WVDP, samples are collected and analyzed by the New York State Department of Health (NYSDOH) at the two stream sampling points that receive drainage from the south plateau, WNFRC67 and WNERB53.

NRC-Licensed Disposal Area. Sampling point WNNDATR is a sump at the lowest point in the collection trench system that intercepts groundwater from the northeastern and northwestern sides of the NDA. Water collected underground at this location is pumped to the LLWTF for treatment prior to discharge at outfall WNSP001. (See Chapter 1 and Chapter 4 for an explanation of the NDA Interceptor Trench and Pretreatment System.) If contamination were to migrate through the NDA, it would most likely be first detected in samples from WNNDATR.

Surface water drainage downstream of the NDA is monitored at WNNDADR. Further downstream, water from sampling point WNERB53 in Erdman Brook, which represents surface waters from the NDA before they join with drainage from the main plant and lagoon areas, is also monitored. Some drainage from western and northwestern portions of the SDA also passes through sampling points WNNDADR and WNERB53. (See Appendix C-4.)

Annual concentrations from WNNDATR are listed in Appendix C-3[CD] and quarterly results are listed under "NDATR" in Appendix E[CD].

No gross alpha or cesium-137 activity was detected at WNNDATR, WNNDADR, and WNERB53 in 2004. No iodine-129 was detected at WNNDATR and WNNDADR in 2004. (Samples from WNERB53 are not analyzed for iodine-129.) Strontium-90 and associated gross beta results at all three locations were elevated with respect to background (WFBCBKG), but all were far below the strontium-90 DCG. Residual soil contamination from past waste burial activities is thought to be the source of the strontium-90 activity. The NDA is thought to be the predominant source of gross beta activity observed at WNNDATR.

Although tritium concentrations at WNNDATR and WNNDADR were also elevated with respect to background values (those from WNERB53 were not), the maximum concentrations from both WNNDATR and WNNDADR were less than 1% of the DCG for tritium in water (2E-03 µCi/mL). Allowing for seasonal variations, tritium concentrations seem to be generally decreasing at both WNNDATR and WNNDADR. Since the half-life of tritium is slightly longer than 12 years, decreasing tritium concentrations may be partially attributable to radioactive decay.

New York State-Licensed Disposal Area. Point WNSDADR is used to monitor drainage from trench covers on the southwestern area of the SDA. Immediately south of the SDA, and upstream of WNSDADR, sampling point WNDCELD is used to monitor surface drainage from the area around the drum cell (Fig. A-2). To the northeast, sampling point WNFRC67, in Frank's Creek, is used to monitor drainage downstream of the drum cell and the eastern and southern borders of the SDA. Summaries of results from WNSDADR, WNDCELD, and WNFRC67 may be found in Appendices C-3[CD] and C-4[CD].

Gross beta and tritium concentrations at WNSDADR, although higher than background concentrations, were a small percentage of the DCGs. All other radiological results from surface waters at the SDA were statistically indistinguishable from background.

Ponded (Standing) Waters. Four ponds near the site were tested in 2004. For comparison, a background pond 8.8 miles (14.1 kilometers [km]) north of the Project was also tested. (See Figs. A-2, A-3, and A-13 for the locations of the five ponds and Appendix C-4[CD] for a summary of sampling results.) All radiological results were statistically the same as concentrations in the background pond.

Off-Site Surface Water. Samples of surface water are collected at four off-site locations, two on Buttermilk Creek and two on Cattaraugus Creek. Off-site sampling locations are shown on Fig. A-3.

Fox Valley Road and Thomas Corners Bridge Sampling Locations. Buttermilk Creek is the major surface drainage from the WNYNSC. One monitoring station is located upstream of the WVDP at Fox Valley Road (WFBCBKG) and one is located downstream at Thomas Corners Bridge (WFBCTCB). The Thomas Corners Bridge sampling location is upstream of Buttermilk Creek's confluence with Cattaraugus Creek. This sampling location represents an important intercept point in the pathway to humans because dairy cattle have access to the water here. A listing of radionuclide concentrations at background location WFBCBKG compared with those downstream at WFBCTCB may be found in Appendix C-4[CD].

Gross alpha, tritium, technetium-99, and cesium-137 concentrations at Thomas Corners Bridge were statistically indistinguishable from background con-

centrations in 2004. Gross beta and strontium-90 concentrations at Thomas Corners Bridge, although detected at less than 2% of the strontium-90 DCG, were elevated in comparison to background. These elevated concentrations may be attributed to small amounts of radioactivity moving from the site via Frank's Creek.

Cattaraugus Creek at Felton Bridge and Bigelow Bridge Sampling Locations. Radiological data from samples taken at Felton Bridge (WFFELBR), downstream of the point where Buttermilk Creek enters Cattaraugus Creek, and from Bigelow Bridge (WFBIGBR), upstream of this point, are summarized in Appendix C-4[CD].

No statistically significant differences were noted between upstream and downstream concentrations of gross alpha, tritium, strontium-90, and cesium-137. Gross beta concentrations at Felton Bridge (WFFELBR), however, were slightly higher than background concentrations, although detected at less than 1% of the DOE DCG for strontium-90.

Figure 2-2 shows gross alpha, gross beta, and tritium results over the past ten years at Felton Bridge. For the most part, tritium concentrations represent detection limits and not detected radioactivity. Taking into account seasonal fluctuations, gross beta activity appears to have remained relatively constant at this location over the last decade.

Overview of Drinking Water Monitoring

Drinking water (potable water) is sampled both off site (near the WVDP) and on site. Off-site drinking water samples are taken from wells that represent the nearest unrestricted use of groundwater near the Project; none of these wells draw from groundwater units underlying the site. Drinking water and utility water for the Project are drawn from two on-site surface water reservoirs.

On-Site Tap Water. On-site drinking water sources were monitored for radionuclides at four

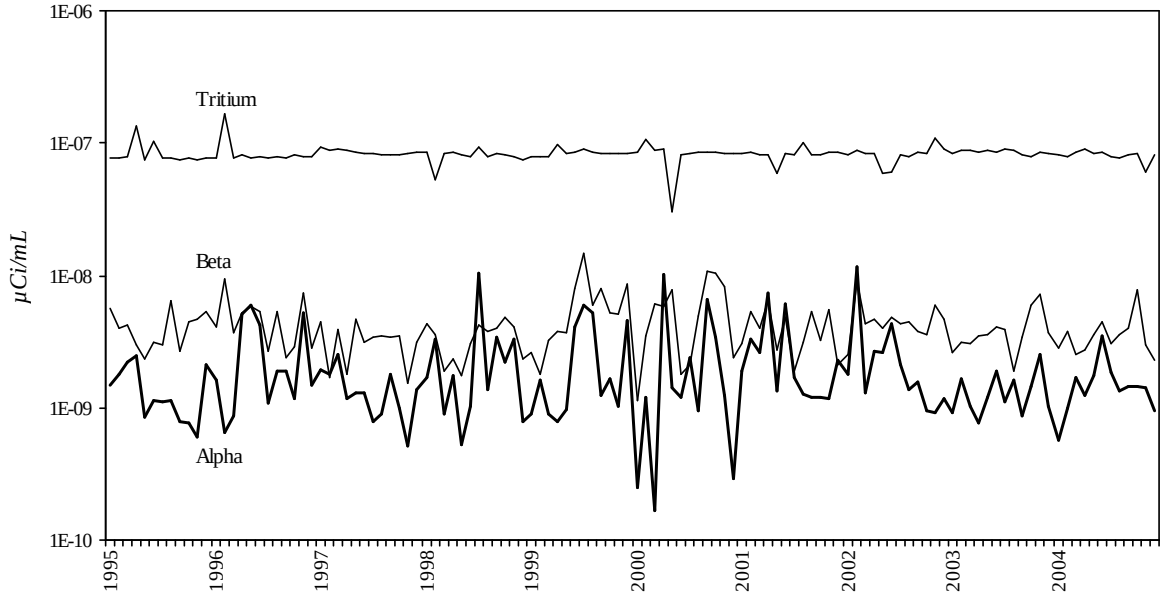


Figure 2-2. Ten-Year Trends of Gross Alpha, Gross Beta, and Tritium Concentrations at Sampling Location WFFELBR

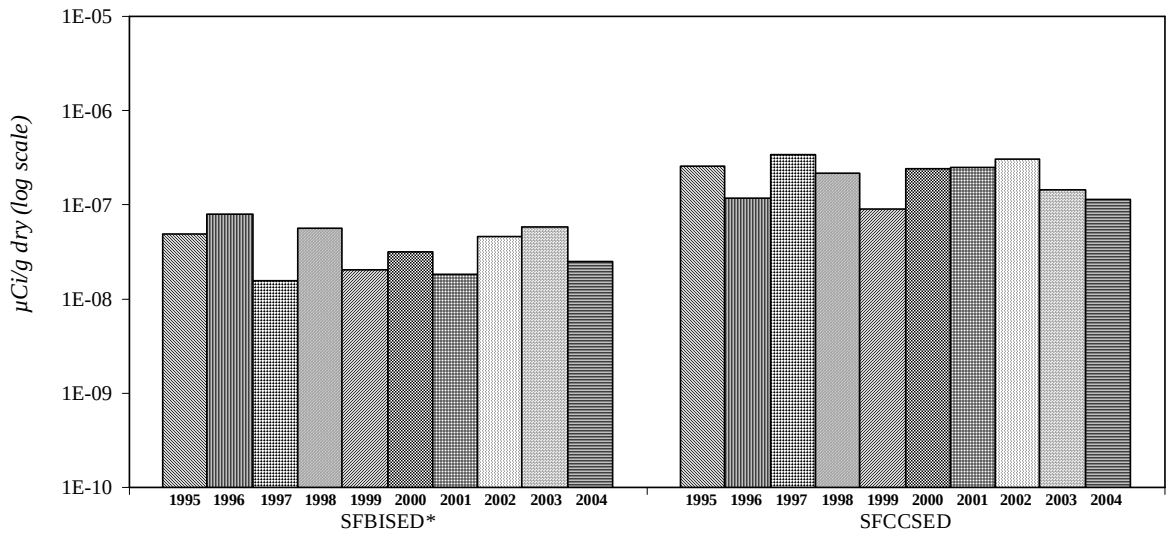
locations: the entry point at the utility room (WNDNKUR), the Environmental Laboratory (WNDNKEL), the maintenance shop (WNDNKMS), and the main plant (WNDNKMP). No differences were noted between control values at the utility room and those from other site locations. Data tables may be found in Appendix C-5CD.

Off-Site Drinking Water Wells. Nine off-site private, residential groundwater wells between 0.9 miles (1.5 km) and 4.3 miles (7 km) from the facility (WFWEL01 through WFWEL05 and WFWEL07 through WFWEL10) were sampled for radiological parameters in 2004. A tenth private well (WFWEL06), 18 miles (29 km) south of the site, provides a background sample. Sampling locations are shown in Figures A-9, A-12, and A-13 and results are presented in Appendix C-5CD. Radiological results in 2004 were close to or statistically indistinguishable from background.

Overview of Sediment Monitoring

Particulate matter in streams can adsorb radiological constituents in liquid effluents, settle on the bottom of the stream as sediment, and subsequently be eroded or resuspended, especially during periods of high stream flow. These resuspended sediments may provide a pathway for radiological constituents to reach humans either directly via exposure or indirectly through the food pathway.

On-Site Sediments. Sediments are collected at three on-site surface water sampling points where liquid effluents leaving the site are most likely to be radiologically contaminated: Frank's Creek where it leaves the security fence (SNSP006), the north swamp drainage swale (SNSW74A), and the northeast swamp drainage swale (SNSWAMP) (Fig. A-2). (Note that swamp sediment samples may be partially composed of soils.) Results from radiological analyses of these samples are listed in Appendix G-2CD. As in previous years, gross beta,



** Background (upstream) location*

Figure 2-3. Ten-Year Trends of Cesium-137 in Stream Sediments at One Location Upstream and One Location Downstream of the WVDP

strontium-90, cesium-137, and certain alpha isotopic results higher than background were noted.

Off-Site Sediments. Sediments are collected off site at three locations downstream of the WVDP: Buttermilk Creek at Thomas Corners Road (SFTCSED), Cattaraugus Creek at Felton Bridge (SFCCSED), and Cattaraugus Creek at the Springville dam (SFSDSED). The first two points are at water sampling locations. The third is behind the Springville dam where significant sediments accumulate, including sediments that may have adsorbed radionuclides from the site. Sediments are also collected at two locations upstream of waters receiving effluents from the WVDP, Buttermilk Creek at Fox Valley Road (SFBCSED) and Cattaraugus Creek at Bigelow Bridge (SFBISED). The two upstream locations provide background data for comparison with downstream points (Fig. A-3).

Most radiological results from downstream sediment sampling sites were statistically the same as those from background locations, except for cesium-137 concentrations that were statistically higher than background. A comparison of annual averaged cesium-137 concentrations from 1995 through 2004 for two off-site sampling locations is illustrated in Figure 2-3. As the figure indicates, cesium-137 concentrations are relatively stable at the background location (SFBISED) and are generally higher at the location downstream of the WVDP (SFCCSED). Although cesium-137 activity historically is elevated in downstream Cattaraugus Creek sediments relative to upstream sediments, the levels are far lower than those of naturally occurring gamma emitters, such as potassium-40.

Overview of Air Emission and Ambient Air Monitoring

Permits obtained from the EPA allow air containing small amounts of radioactivity to be released from plant ventilation stacks during normal operations. The air released must meet criteria specified in the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations to ensure that the environment and the public's health and safety are protected. Dose-based comparisons of WVDP emissions against NESHAP criteria are presented later in this chapter. (See Predicted Dose From Airborne Emissions, later in this chapter.)

Unlike NESHAP dose criteria, the DOE DCGs are expressed in units of µCi/mL and therefore can be directly compared with concentrations of radionuclides in WVDP air emissions. DOE standards and DCGs for radionuclides of interest at the WVDP are found in Appendix K. When isotopic data are not available, gross alpha and beta measurements are assumed to come from americium-241 and strontium-90, respectively, because the DCGs for these radionuclides are the most limiting for major particulate emissions at the WVDP.

Ventilation and Emission Systems. The exhaust from each EPA-permitted ventilation system on site is continuously filtered and the permanent systems are monitored as air is released to the atmosphere. Because radionuclide concentrations in air emissions are quite low, a large volume of air must be sampled at each point to measure the quantity of specific radionuclides released from the facility. Emissions are sampled for both particulate (e.g., strontium-90 and americium-241) and gaseous forms of radioactivity (e.g., tritium and iodine-129). The total release of each radionuclide (in curies) varies from year to year in response to changing site activities. For instance, releases of

iodine-129 decreased after vitrification was completed, while releases of tritium, strontium-90, cesium-137, and alpha isotopes generally increased when decontamination and dismantlement activities began. (Note that calculated dose has remained a small fraction of the standard. See "Predicted Dose From Airborne Emissions" later in this chapter.)

The Main Plant Ventilation Stack. The main plant ventilation stack (ANSTACK) is the primary source of airborne releases at the WVDP. This stack, which vents to the atmosphere at a height of approximately 200 feet (more than 60 meters), releases ventilation exhaust from several facilities, including the liquid waste treatment system, the analytical laboratories, and off-gas from the former vitrification system.

Total curies released from the main stack in 2004 are listed in Appendix D, together with annual averages, maxima, and a comparison of average isotopic concentrations with the applicable DCGs. As in previous years, the 2004 average radioactivity levels at the stack discharge point were already below concentration guidelines for airborne radioactivity in an unrestricted environment. Airborne concentrations from the stack to the site boundary are further reduced via dispersion by a factor of more than 200,000. Results from air samples taken just outside the site boundary confirm that WVDP operations had no discernible effect on off-site air quality. (See "Perimeter and Remote Ambient Air Monitoring," later in this chapter.)

Other On-Site Air Sampling Systems. Sampling systems similar to those of the main stack monitor airborne effluents from the former vitrification heating, ventilation, and air-conditioning system (ANVITSK), the 01-14 building ventilation stack (ANCSSTK), the contact size-reduction facility ventilation stack (ANCSRFK), the supernatant treatment system ventilation stack (ANSTSTK), the container sorting and packaging facility ventilation stack (ANCSPFK), and the remote-handled waste facility (ANRHWFK), which began "hot" operations in June 2004 (Fig. A-4).

Appendix D presents total radioactivity released for specific radionuclides (as available) at each of these sampling locations. Samples from locations ANVITSK, ANCSSTK, ANSTSTK, ANCSPFK, and ANRHWFK occasionally showed detectable concentrations of gross radioactivity, as well as specific beta- and alpha-emitting radionuclides, but none approached any DOE effluent limitations. (ANCSRFK did not operate in 2004, therefore no samples were taken.)

Permitted portable outdoor ventilation enclosures (OVEs) are used occasionally to provide the ventilation necessary for the safety of personnel working with radioactive materials in areas outside permanently ventilated facilities or in areas where permanent ventilation needs to be augmented. In 2004, decontamination of extraction cell 2 in the main plant was monitored by OVEs. Air samples from OVEs are collected continuously while those emission points are discharging, and data from these portable ventilation units are included in annual airborne emission evaluations. Average discharges from OVEs were well below DOE guidelines.

Three air samplers monitor ambient air near three on-site waste storage units – the lag storage area (ANLAGAM), the NDA (ANNDAAM), and the SDA (ANSDAT9) (Fig. A-4). These samplers were put in place to monitor potential diffuse releases of radioactivity. Monitoring data from these locations are presented in Appendix D.

With the exception of tritium results at ANSDAT9, radiological data sets for the three locations were statistically indistinguishable from results for the background air monitoring location at Great Val-

ley (AFGRVAL). Although tritium results at ANSDAT9 were elevated with respect to background, even the highest result (5.51E-12 µCi/mL [2.04E-01 Bq/m^3]) was less than 0.01% of the DOE DCG for tritium in air (1E-07 µCi/mL).

Perimeter and Remote Ambient Air Monitoring. In 2004, samples for radionuclides in air were collected at six locations around the perimeter of the site and at three remote locations. Maps of the sampling locations are found on Figures A-5, A-12, and A-13.

The perimeter locations on Fox Valley Road (AFFXVRD), Rock Springs Road (AFRSPRD), Route 240 (AFRT240), Thomas Corners Road (AFTCORD), Dutch Hill Road (AFBOEHN), and at the site's bulk storage warehouse (AFBLKST) were chosen because they provide historical continuity (as former Nuclear Fuel Services, Inc. sampling locations) or because they represent the most likely locations for detecting off-site airborne concentrations of radioactivity.

The remote locations provide data from nearby communities (West Valley [AFWEVAL] and Springville [AFSPRVL]) and from a more distant background area (Great Valley [AFGRVAL], 18 miles [29 km] south of the site), which is considered representative of regional background air. Data from these locations are presented in Appendix D[CD].

Ten-year gross alpha and gross beta concentrations at the Rock Springs Road location are shown in Figure 2-4. Within a range of seasonal and weekly fluctuations, the concentrations have been relatively constant over the past ten years.

Radioisotopic results from samples taken at the two near-site communities and from the site perimeter were statistically indistinguishable from results from the background samples, suggesting that there is no adverse site influence on the air quality at these near-site locations.

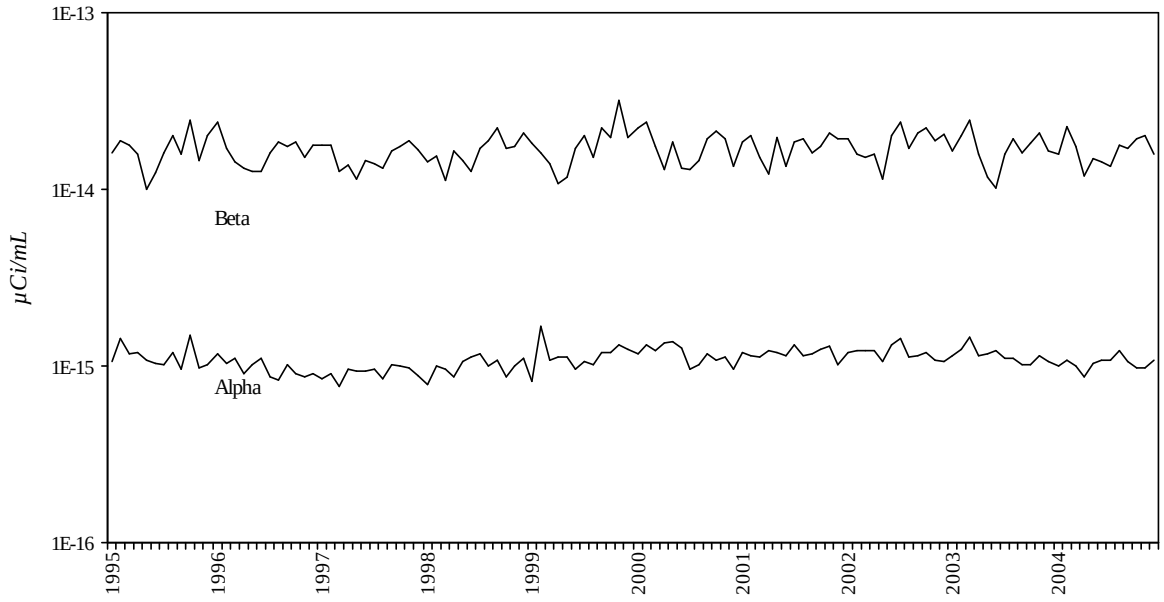


Figure 2-4. Ten-Year Trends of Gross Alpha and Gross Beta Concentrations at Rock Springs Road (AFRSPRD)

Atmospheric Deposition and Soil Monitoring

Fallout Pots. Fallout samples are analyzed to monitor short-term deposition of radionuclides at four of the perimeter air sampler locations and at one on-site location near the rain gauge outside of the Environmental Laboratory (Figs. A-4 and A-5). The data from precipitation analyses are presented in Appendix D[CD]. The low levels of radioactivity released in main stack emissions did not measurably affect on-site or perimeter fallout pot samples in 2004.

Off-Site Surface Soil. Surface soil near the off-site air samplers is collected to assess long-term deposition of radionuclides. Maps of the off-site surface soil sampling locations are on Figures A-3, A-12, and A-13.

The measured concentrations of most site-related radionuclides in soils from the perimeter and community locations (Appendix G-2[CD]) were statistically indistinguishable from regional background concentrations. Elevated gross beta concentrations were noted at Thomas Corners, consistent with historical data from this soil sampling location.

Overview of Food Chain Monitoring

Each year food samples are collected from locations near the site (Fig. A-9) and from remote locations (Figs. A-12 and A-13). Fish and deer are collected during periods when they would normally be taken by sportsmen for consumption. Corn, apples, and beans are collected annually at the time of harvest. (See Measurement of Radionuclide Concentrations in Food, later in this chapter, for a discussion of estimating doses from foodstuffs.) Results are listed in Appendix F[CD].

Fish. Fish are obtained under a collector's permit by electrofishing, a method that temporarily stuns the fish, allowing them to be netted for collection. Electrofishing allows more efficient species-selective control than sport fishing, with unwanted fish being returned to the creek essentially unharmed.

Fish were collected from three locations in Cattaraugus Creek in 2004: ten fish were collected at each of two locations downstream of WNYNSC drainage – one above the Springville dam (BFFCATC) and one below the Springville dam (BFFCATD). Ten more fish were collected upstream of the site (BFFCTRL). The fish taken below the dam (BFFCATD) included species that migrate about 40 miles (more than 60 km) upstream from Lake Erie.

Strontium-90 results from fish downstream of the site (BFFCATC) were elevated in comparison with the background results (BFFCTRL). No other results were statistically higher than background. All results were within the range of historical values.

Venison. Radionuclide data for venison samples were taken from vehicle-deer accidents around the WNYNSC and from deer collected far from the site in the towns of Farmersville, Allegany, and Machias, New York .

Although the cesium-137 results for one near-site deer was elevated with respect to background, the result was consistent with historical results. The remainder of the data from 2004 show no statistical differences between concentrations of radionuclides in near-site and control samples.

From 1994 through 2004 (except 2001), during the big-game hunting season, hunters were allowed access to designated areas within the WNYNSC, excluding the WVDP premises, in a controlled hunting program established by NYSERDA. (The hunt

was canceled in 2001 because of heightened security concerns.) Data from previous hunts have shown that concentrations of radioactivity in deer flesh have been very low, indicating that Project activities have little or no effect on the local herd.

Beef. No significant differences were found between results from near-site and background samples.

Milk. Near-site sample results were indistinguishable from background control sample results.

Vegetables and Fruit. WVDP-related nuclides in results from sweet corn, beans, and apples collected at harvest time were statistically the same as measurements from background samples.

Direct Environmental Radiation Monitoring

Monitoring points are located on site at the waste management units, at the site security fence, around the WNYNSC perimeter and the access road, and at a background location remote from the WVDP (Figs. A-10 through A-13). The identification numbers associated with each location were assigned in chronological order of original installation.

Quarterly and annual averages of thermoluminescent dosimeter (TLD) measurements at off-site and on-site locations are noted in Appendix H[CD]. The results of measurements in 2004 show typical seasonal variations and are similar to results from previous years.

On-Site Radiation Monitoring. As in past years, the on-site monitoring point with the highest dose readings was location #24. Sealed containers of radioactive components and debris from the plant decontamination work are stored nearby.

The average exposure rate at location #24 was about 475 milliroentgens (mR) per quarter (216 microroentgen per hour [µR/hr]) during 2004, slightly lower than the exposure rate in 2003 (231 µR/hr). Exposure rates at this location have been generally decreasing over time because the radioactivity in the materials stored nearby is decaying.

The on-site monitoring point with the second highest dose readings (location #40) was near the waste tank farm. The average exposure rate at location #40 in 2004 was about 112 mR/quarter (51 µR/hr), the same as in 2003. As expected, results from TLDs located near on-site facilities are generally higher than background results, however, these TLD locations are well within the WNYNSC boundary and are not accessible by the public.

In 2004, increases in exposure rates near the drum cell and at another location near the main plant (DNTLD38) were thought to be attributable to the movement past and storage of sodium-bearing radioactive waste containers near these monitoring points. Even though increases were noted at these two locations, no comparable exposure increases were noted at TLDs on the site perimeter.

Perimeter and Off-Site Radiation Monitoring. The perimeter TLDs (TLDs #1–16 and #20) are distributed in the16 compass sectors around the facility near the WNYNSC boundary. Results from the perimeter and community TLDs were statistically the same as results from the background TLD. The perimeter TLD quarterly averages shown on Figure 2-5 indicate seasonal fluctuations but no long-term trends. The quarterly average of the 17 WNYNSC perimeter TLDs was 16.1 mR per quarter (7.4 µR/hr) in 2004, slightly lower than in 2003.

Confirmation of Results. Performance of the environmental TLDs is confirmed periodically using a portable high-pressure ion chamber (HPIC) detection system. The TLD results include the entire third quarter of 2004; the HPIC results were collected over a period of less than 30 minutes.

Since these measurements are made with different systems and over differing periods of time, they are not directly comparable. The average relative percent difference between the two sets of measurements was about 28%, indicating general agreement between these two different measurement methods. (Guidance in American National Standards Institute N545-1975, the standard for environmental dosimetry, uses measurement agreement within 30% total uncertainty as a performance specification for TLD measurements.)

Meteorological Monitoring

Meteorological monitoring at the WVDP provides representative and verifiable data that characterize the local and regional climatology. These data are used primarily to assess potential effects of routine and nonroutine releases of airborne radioactive materials and to develop dispersion models used to calculate the effective dose equivalent to off-site residents. Since dispersive capabilities of the atmosphere are dependent upon wind speed, wind direction, and atmospheric stability (which includes a function of the difference in temperature between two elevations), these parameters are closely monitored and are available to the emergency response organization at the WVDP. The on-site 197-ft (60-m) meteorological tower (Fig. A-1) continuously monitors wind speed, wind direction, and temperature at both the 197-ft (60-m) and 33-ft (10-m) elevations. In addition, an independent, remote 33-ft (10-m) meteorological station, located approximately 5 miles (8 km) south of the site on a hillcrest on Dutch Hill Road (Fig.

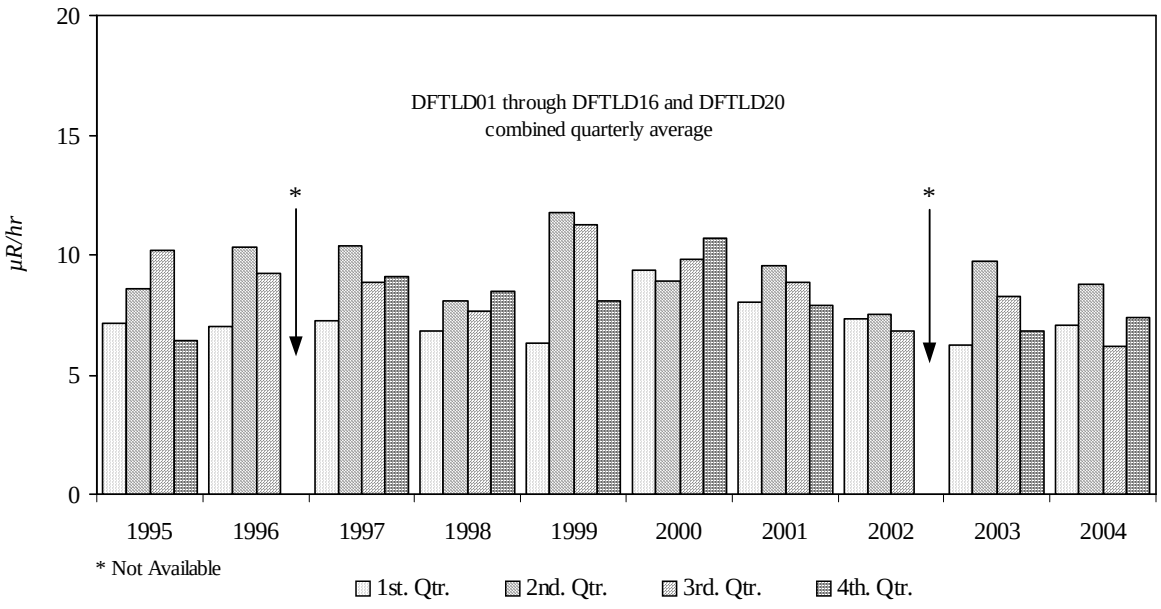


Figure 2-5. Ten-Year Trends of Environmental Radiation Levels at Perimeter TLDs

A-12), continuously monitors wind speed and wind direction. Dewpoint, precipitation, and barometric pressure are also monitored on site.

The two meteorological locations supply data to the primary digital and analog data acquisition systems located within the Environmental Laboratory. On-site systems are provided with either uninterruptible or standby power backup in case of site power failures. In 2004, the on-site system data recovery rate (the time valid data were logged versus the total elapsed time) was approximately 93.1%. Regional data at the 33-ft (10-m) elevation and mean wind speed and wind direction at the 33-ft and 197-ft (10-m and 60-m) elevations at the on-site tower during 2004 are shown in Appendix I.

Weekly and cumulative total precipitation data are presented in Appendix I. Precipitation in 2004 was approximately 43.2 inches (110 cm), about 5% more than the long-term annual average (41.0 inches [104 cm]).

Documentation, such as meteorological system calibration records, site log books, and analog strip charts, is stored in protected archives. Meteorological towers and instruments are examined three times per week for proper function and are calibrated semiannually and/or whenever instrument maintenance might affect calibration.

Special Monitoring

Special monitoring comprises sampling and analyses not covered by the routine environmental monitoring program but that address items of environmental interest. Special monitoring programs are used to verify and/or track these items. Some special environmental monitoring was carried out in 2004 associated with a breach of the laundry waste water line (see "RCRA 3008[h] Administrative Order on Consent" and "Process Sewer Integrity Evaluation" in the Environmental Compliance Summary) and with rehabilitation of the railroad spur (see "Soil and Sediment Monitoring" in Chapter 3).

Radiological Effluents and Dose

Dose Assessment Methodology

The potential radiation dose to the general public from activities at the WVDP is evaluated by using a two-part methodology applied in a manner consistent with the requirements of DOE Order 5400.5. The first part uses the measurements of radionuclide concentrations in liquid and air released from the Project to determine annual total effect. The second part uses measurements of radioactivity in food from locations near the Project boundaries to evaluate the impact of the annual total release.

Radiological dose is evaluated for all major exposure pathways, including external irradiation, inhalation, and ingestion of local food products. The dose contributions from each radionuclide and pathway combination are then combined to obtain the total dose estimates reported in Table 2-3.

Measurement of Radionuclide Concentrations in Liquid and Air Releases. Because it is difficult to distinguish the health effects of the small amount of radioactivity originating from the Project and naturally occurring radiation in the environment, computer codes are used to model the environmental dispersion of radionuclides that originate from on-site monitored ventilation stacks and liquid discharge points.

Actual data from release-monitoring samples are collected, together with annual weather measurements and the most recent demographic information. (See Appendices C, D, and I.) The effective dose equivalent (EDE) to the maximally exposed off-site individual (MEOSI) and the collective EDE to the population within a 50-mile (80-km) radius are then calculated using conservative models that have been approved by the DOE and the EPA to demonstrate compliance with radiation standards. (See the inset on Radiation Dose and Units of Dose Measurement.)

Measurement of Radionuclide Concentrations in Food. The second part of the dose assessment is based on actual measurements of radioactivity in samples of foodstuffs grown in the vicinity of the WVDP and the comparison of these values with measurements of samples collected from locations well beyond the potential influence of site effluents.

If any of the near-site food samples contain radionuclide concentrations that are statistically higher than the concentrations in control samples, separate dose calculations are performed to verify that the calculated foodstuff dose is within the dose range estimated by computer modeling. (See Calculated Dose From Local Foodstuff Tests, later in this chapter.)

These estimates show that the concentrations of radioactivity, whether from sites near the WVDP or from distant locations, are small – usually near the analytical detection limits – thereby providing additional assurance that operations at the WVDP are not adversely affecting the public.

These calculated doses are used as an independent confirmation of (not added to) the computer-modeled estimates (Table 2-3) because the models already include contributions from all environmental pathways.

Radiation Dose

The energy released from a radionuclide is eventually deposited in matter encountered along the path of the radiation. The radiation energy absorbed by a unit mass of material is referred to as the absorbed dose. The absorbing material can be either inanimate matter or living tissue.

Alpha particles leave a dense track of ionization as they travel through tissue and thus deliver the most dose per unit path-length. However, alpha particles are not penetrating and must be taken into the body by inhalation or ingestion to cause harm. Beta and gamma radiation can penetrate the protective dead skin layer of the body from the outside, resulting in exposure of the internal organs to radiation.

Because beta and gamma radiations deposit much less energy in tissue per unit path-length relative to alpha radiation, they produce fewer biological effects for the same absorbed dose. To allow for the different biological effects of different kinds of radiation, the absorbed dose is multiplied by a quality factor to yield a unit called the dose equivalent. A radiation dose expressed as a dose equivalent, rather than as an absorbed dose, permits the risks from different types of radiation exposure to be compared with each other (e.g., exposure to alpha radiation compared with exposure to gamma radiation). For this reason, regulatory agencies limit the dose to individuals in terms of total dose equivalent.

Units of Dose Measurement

The unit for dose equivalent in common use in the U.S. is the rem, which stands for roentgen equivalent man. The international unit of dose equivalent is the sievert (Sv), which is equal to 100 rem. The millirem (mrem) and millisievert (mSv), used more frequently to report the low dose equivalents encountered in environmental exposures, are equal to one-thousandth of a rem or sievert, respectively. Other radioactivity unit conversions are found on p. UOM-2 at the back of this report.

The effective dose equivalent (EDE), also expressed in units of rem or sievert, provides a means of combining unequal organ and tissue doses into a single "effective" whole body dose that represents a comparable risk probability. The probability that a given dose will result in the induction of a fatal cancer is referred to as the risk associated with that dose. The EDE is calculated by multiplying the organ dose equivalent by the organ-weighting factors developed by the International Commission on Radiological Protection (ICRP) in Publications 26 (1977) and 30 (1979). The weighting factor is a ratio of the risk from a specific organ or tissue dose to the total risk resulting from an equal whole body dose. All organ-weighted dose equivalents are then summed to obtain the EDE.

The dose from internally deposited radionuclides calculated for a fifty-year period following intake is called the fifty-year committed effective dose equivalent (CEDE). The CEDE sums the dose to an individual over fifty years to account for the biological retention of radionuclides in the body. The total EDE for one year of exposure to radioactivity is calculated by adding the CEDE to the dose equivalent from external, penetrating radiation received during the year. Unless otherwise specified, all doses discussed here are total EDE values, which include the CEDE for internal emitters.

A collective population dose is expressed in units of person-rem or person-sievert because the individual doses are summed over the entire potentially exposed population. The average individual dose can therefore be estimated by dividing the collective dose by the population.

Predicted Dose From Airborne Emissions

Airborne emissions of radionuclides are regulated by the EPA under the Clean Air Act and its implementing regulations. DOE facilities are subject to 40 Code of Federal Regulations (CFR) 61, Subpart H, NESHAP. Subpart H contains the national emission standards for emissions of radionuclides other than radon from DOE facilities. The applicable standard for radionuclides is a maximum of 10 mrem (0.1 mSv) effective dose equivalent to any member of the public in any year.

Releases of airborne radioactive materials in 2004 from nominal ground-level stacks (1 to 24 meters high) and from the main 60-meter-high stack were modeled using the EPA-approved CAP88-PC computer code (Parks, June 1997). This air dispersion code estimates effective dose equivalents for the ingestion, inhalation, air immersion, and ground surface pathways.

Site-specific data for CY 2004 non-radon radionuclide releases in curies per year are listed in Appendix D[CD]. Applicable information from these tables was used as input to the CAP88-PC code, as were wind data collected from the on-site meteorological tower during 2004 and current local population distribution information.

Resulting output from the CAP88-PC code was then used to determine the total EDE from air emissions to a maximally exposed individual and the collective dose to the population within a 50-mile (80-km) radius of the WVDP.

Maximum Dose to an Off-Site Individual. Based on the non-radon airborne radioactivity released from all sources at the site during 2004 (i.e., permitted stacks, stacks that do not require permits, and non-point sources), it was estimated that a person living in the vicinity of the WVDP could have received a total EDE of 0.0015 mrem (0.000015 mSv) from airborne releases. The computer model estimated that this MEOSI was located 1.2 miles (1.9 km) north-northwest of the site and was assumed to eat only locally-produced foods. More than 50% of the dose from main plant stack emissions was from iodine-129.

The maximum total EDE of 0.00078 mrem (0.0000078 mSv) from the permitted stacks and vents is far below levels that could be directly measured at the exposed individual's residence. This dose is comparable to about one and one-half minutes of natural background radiation received by an average member of the U.S. population and is well below the 10 mrem (0.1 mSv) NESHAP limit promulgated by the EPA and mandated by DOE Order 5400.5.

Collective Population Dose. The CAP88-PC program was used to estimate the collective EDE to the population. Based upon the latest U.S. census population data collected in CY 2000, 1.54 million people were estimated to reside within 50 miles (80 km) of the WVDP. This population received an estimated 0.012 person-rem (0.00012 person-Sv) total EDE from radioactive non-radon airborne effluents released from WVDP point and diffuse sources during 2004. (See the discussion of radon-220 later in this chapter.) The resulting average EDE per individual was 0.000008 mrem (0.00000008 mSv).

Iodine Emissions From the Main Stack. In the ten-year period before the startup of vitrification, iodine-129, a long-lived radionuclide, was found in main stack emissions at levels of approximately 0.007 to 0.057 mCi/year. In 1996, when vitrification operations began, 1.20 mCi of iodine-129 were released and in 1997, the first full year of vitrification, a maximum release of 7.4 mCi was observed. The increase occurred because gaseous iodine was not as efficiently removed by the vitri-

Table 2-3
Summary of Annual Effective Dose Equivalents to an Individual and Population From WVDP Releases in 2004

Exposure Pathways	Annual Effective Dose Equivalent	
	Maximally Exposed Off-Site Individual[1] mrem (mSv)	***Collective Effective Dose Equivalent[2] person-rem (person-Sv)***
Airborne Releases[3]	1.5E-03 (1.5E-05)	1.2E-02 (1.2E-04)
% EPA standard (10 mrem)	0.02%	NA
Waterborne Releases[4]		
Effluents only	1.6E-02 (1.6E-04)	1.5E-02 (1.5E-04)
Effluents plus north plateau drainage	4.7E-02 (4.7E-04)	1.9E-01 (1.9E-03)
Total from all Pathways	4.9E-02 (4.9E-04)	2.0E-01 (2.0E-03)
% DOE standard (100 mrem) – air and water combined	0.05%	NA
% of natural background (295 mrem; 453,000 person-rem) – received from air and water combined	0.02%	0.00005%
Estimated Airborne Radon-220[5]	1.2E-02 (1.2E-04)[6]	3.4E-01 (3.4E-03)

NA - Not applicable. Numerical regulatory standards are not set for the collective EDE to the population.

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[1] *The maximum exposure to air discharges is estimated to occur at a residence 1.9 kilometers north-northwest of the main plant building.*

[2] *A population of 1.54 million is estimated to reside within 80 kilometers of the site.*

[3] *Releases are from atmospheric non-radon point and diffuse sources. Calculations use CAP88-PC to estimate individual and population doses. EPA and DOE limits for individual airborne dose are the same.*

[4] *Estimates are calculated using the methodology described in the WVDP Manual for Radiological Assessment of Environmental Releases at the WVDP (WVNSCO, 2003).*

[5] *Estimated airborne releases are based on indicator measurements and process knowledge. Dose estimates are calculated using CAP88-PC.*

[6] *The estimated dose from radon-220 is specifically excluded by rule from NESHAP totals.*

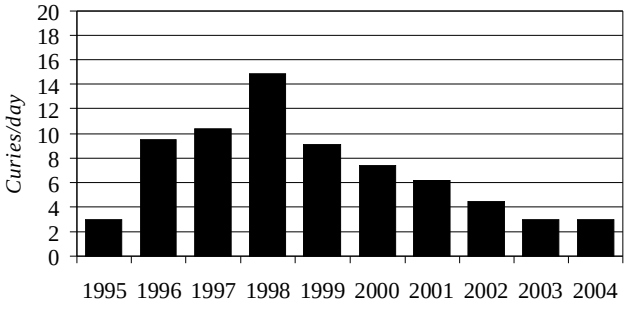
Radon-220

Radon-220 is a naturally occurring gaseous decay product of thorium-232 present in the airborne emissions from the WVDP main plant. Radon-220, also known as thoron, is associated with the thorium reduction extraction (THOREX)-related thorium-232 and uranium-232 in the high-level waste.

As reported in Chapter 2 of the 1996 WVDP Site Environmental Report (WVNSCO and Dames & Moore, June 1997), thoron levels were observed to increase during startup of the 1996 high-level waste vitrification process. An estimate of the thoron released during each waste concentration cycle was developed and used to determine a theoretical annual release. During the vitrification phase, an average of about 12 curies per day were released. In 2004, with the vitrification process completed, the average was about three curies of thoron released per day.

Although large numbers of curies were released relative to other radionuclides, the calculated dose from thoron is quite small because of its short decay half-life and other characteristics. The NESHAP rule specifically excludes thoron from air emission dose calculations, so a dose estimate using CAP88-PC was calculated separately. The theoretical dose to the MEOSI located 1.2 miles (1.9 km) north-northwest of the site in 2004 would have been 0.012 mrem, and the collective dose to the population within an 80-kilometer radius would have been 0.34 person-rem. (See Table 2-3.) These theoretical doses are within the same range as doses from the man-made radionuclides found in WVDP effluents.

With vitrification completed, thoron releases have decreased to pre-vitrification levels. The figure presented here provides a relative indication of recent trends in the estimated annual thoron releases.



Estimated Radon-220 Releases From the WVDP

fication process off-gas treatment system as were most other radionuclides. As more high-level radioactive waste was vitrified, iodine-129 levels decreased and in 2003, the first full year since vitrification was completed, the total annual release had dropped to 0.065 mCi. In 2004, the total annual release decreased even further to 0.028 mCi. Even so, in 2004, iodine-129 continued to account for the largest proportion of dose to an off-site individual from main stack airborne emissions.

Predicted Dose From Waterborne Releases

Currently there are no EPA standards establishing limits on the radiation dose to members of the public from liquid effluents except as applied in 40 CFR 141 and 40 CFR 143, Drinking Water Guidelines (EPA, 1984a; 1984b). Corollary limits for community water supplies are set by NYSDOH in the New York State Sanitary Code (Title 10 of the Official Compilation of Codes, Rules, and Regulations of the State of New York [NYCRR] 5-

1.52). The private residential potable water wells sampled for radionuclides are upgradient of the WVDP and therefore do not represent a potential source of exposure to radiation from routine Project activities.

Since Cattaraugus Creek is not used as a drinking water supply, a comparison of the predicted concentrations and doses with the 4-mrem/year (0.04-mSv/year) EPA and NYSDOH drinking water limits established in 40 CFR 141 and 40 CFR 143, and in 10 NYCRR §5-1.52, respectively, is not truly appropriate (although the values in creek samples are well below the EPA drinking water limits). The estimated radiation dose was compared to the applicable guidelines provided in DOE Order 5400.5. The EDE to the MEOSI and the collective EDE to the population due to routine waterborne releases and natural drainage are calculated using dose conversion factors as tabulated in the "WVDP Manual for Radiological Assessment of Environmental Releases at the WVDP" (WVNSCO, 2003).

Since the Project's liquid effluents eventually reach Cattaraugus Creek, the most important individual exposure pathway is the consumption of fish from this creek by local sportsmen. It is conservatively assumed that a person may consume annually as much as 46 pounds (21 kg) of fish caught in the creek. Exposure to external radiation from shoreline or water contamination is also included in the model for estimating radiation dose. Population dose estimates assume that radionuclides are further diluted in Lake Erie before reaching municipal drinking water supplies.

The computer codes GENII version 1.485 (Pacific Northwest Laboratory, 1988), which implements the models in NRC Regulatory Guide 1.109 (NRC, 1977), and LADTAP II (Simpson and McGill, 1980) were used to calculate site-specific unit dose factors for routine waterborne releases and dispersion of these effluents. Input data included local stream flow and dilution, drinking water usage, and stream usage factors. (See "WVDP Manual for Radiological Assessment of Environmental Releases at the WVDP" [WVNSCO, 2003] for a detailed description of the GENII code.)

Eight batches of liquid effluents were released from lagoon 3 (point WNSP001) during 2004. Measurements of the radioactivity discharged in these effluents, listed in Appendix C-2CD, were combined with the unit dose factors to calculate the EDE to the MEOSI and the collective EDE to the population living within a 50-mile (80-km) radius of the WVDP.

In addition to measurements from WNSP001, radioactivity measurements from sewage treatment facility effluents (WNSP007) were included in the EDE calculations. Results from the sewage treatment facility are also presented in Appendix C-2CD. (The french drain at WNSP008, a third release point, has been sealed off since 2001 and was not included in this evaluation.)

Besides the two release points at WNSP001 and WNSP007, waters from two natural drainage channels originating on the Project premises contain measurable concentrations of radioactivity: the northeast swamp (WNSWAMP) and north swamp (WNSW74A). (See Northeast Swamp and North Swamp Drainage discussed earlier in this chapter.) The measured radioactivity from these points is reported in Appendix C-3CD. These results are included in the EDE calculations for the MEOSI and the collective population.

There were no unplanned releases of waterborne activity to the off-site environment in 2004. (See "RCRA 3008(h) Administrative Order on Consent" and "Process Sewer Integrity Evaluation" in the Environmental Compliance Summary.)

Maximum Dose to an Off-Site Individual. Based on the radioactivity in liquid effluents discharged from the WVDP (lagoon 3 and the sewage treatment plant) during 2004, an off-site individual could have received a maximum EDE of 0.016 mrem (0.00016 mSv). About 90% of this dose was from cesium-137. The maximum off-site individual EDE due to drainage from the north plateau (north swamp and northeast swamp) was 0.031 mrem (0.00031 mSv).

The combined EDE to the maximally exposed individual from liquid effluents and drainage was 0.047 mrem (0.00047 mSv). This annual dose is very small in comparison to the 295 mrem (2.95 mSv) dose that is received by an average member of the U.S. population from natural background radiation.

Collective Dose to the Population. As a result of radioactivity released in liquid effluents from the WVDP (primarily from lagoon 3) during 2004, the population living within 50 miles (80 km) of the site received a collective EDE of 0.015 person-rem (0.00015 person-Sv). The collective dose to the population from the effluents plus the north plateau drainage was 0.19 person-rem (0.0019 person-Sv). The resulting average EDE from effluent releases and north plateau drainage (north swamp and northeast swamp) per individual is 0.00013 mrem (0.0000013 mSv). This dose is an inconsequential addition to the dose that an average person receives in one year from natural background radiation.

Calculated Dose From Local Foodstuff Tests

As noted in the discussion of food chain monitoring earlier in this chapter, most radionuclide concentrations in near-site food samples were statistically indistinguishable from concentrations in background samples. Strontium-90 concentrations higher than background were noted in fish taken in Cattaraugus Creek downstream of the WVDP (BFFCATC) and cesium-137 higher than background was noted in one near-site deer. Even so, conservative estimates of dose due to consuming near-site fish, deer, beef, milk, beans, corn, and apples were all less than 0.2 mrem/year. These independent estimates confirm the modeled dose estimates based on air and water effluent sampling results as summarized in Table 2-3.

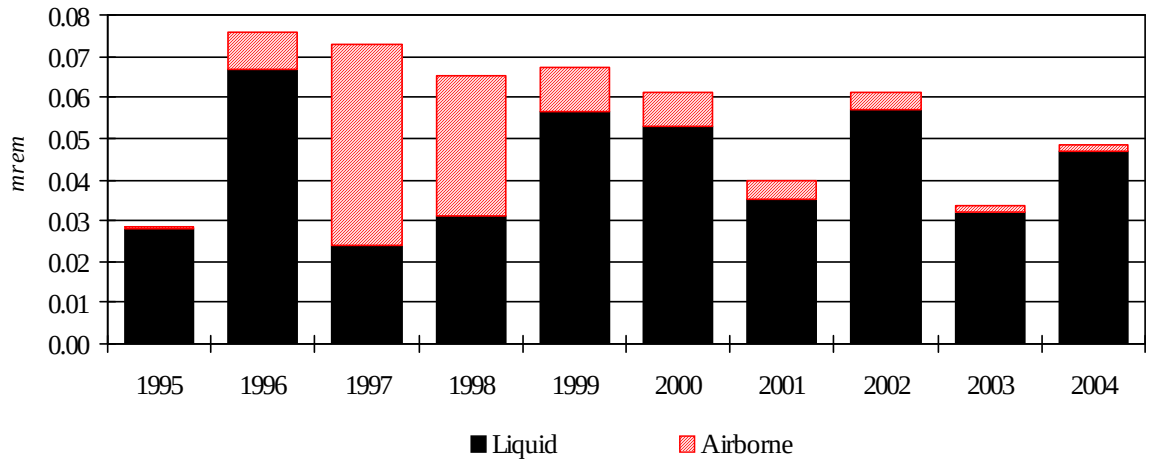


Figure 2-6. Effective Dose Equivalent From Liquid and Airborne Effluents to a Maximally Exposed Individual Residing Near the WVDP

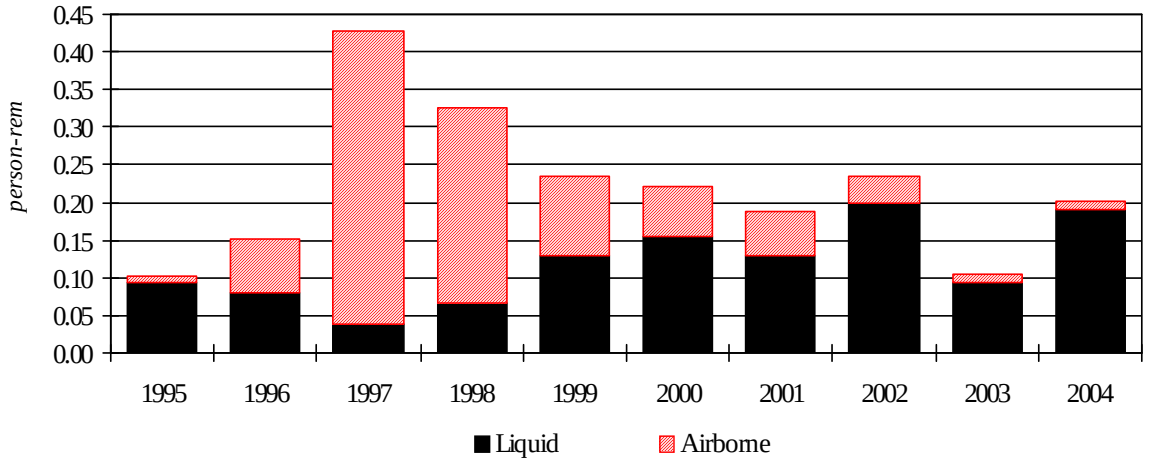


Figure 2-7. Collective Effective Dose Equivalent From Liquid and Airborne Effluents to the Population Residing Within 50 Miles (80 km) of the WVDP

Predicted Dose From All Pathways

The potential dose to the public from both airborne and liquid effluents released from the Project during 2004 is the sum of the individual dose contributions. The calculated maximum EDE from all pathways to a nearby resident was 0.049 mrem (0.00049 mSv). This dose is 0.05% of the 100-mrem (1-mSv) annual limit in DOE Order 5400.5. The estimated dose from radon-220 to the same nearby resident was about 0.01 mrem.

The total collective EDE to the population within 50 miles (80 km) of the site was 0.20 person-rem (0.0020 person-Sv), with an average EDE of 0.0001 mrem (0.000001 mSv) per individual. The estimated radon-220 dose to the population was approximately 0.3 person-rem.

Table 2-3 summarizes the dose contributions from all pathways and compares the individual doses with the applicable standards. The low doses calculated using computer modeling were corroborated by the low or non-detectable doses calculated from local foodstuff test data.

Figure 2-6 shows the calculated annual dose to the hypothetical maximally exposed individual over the last ten years. The estimated dose for 2004 (0.05 mrem) is higher than the annual dose reported for 2003 (0.03 mrem). The decrease in dose fraction from air emissions in 2003 is attributed to the continuing decrease in iodine-129 emissions. Liquid doses, however, were slightly higher in 2004 than in 2003 (0.047 versus 0.032 mrem, respectively).

Figure 2-7 shows the collective dose to the population over the last ten years. (See Fig. A-14 for a map of the population sectors.) The overall radioactivity represented by these data confirms the continued inconsequential addition to the natural background radiation dose that individuals and population around the WVDP receive from Project activities.

Risk Assessment

Estimates of cancer risk from ionizing radiation have been presented by the National Council on Radiation Protection and Measurements (NCRP) (1987b) and the National Research Council's Committee on Biological Effects of Ionizing Radiation (1990).

The NCRP estimates that the probability of fatal cancer occuring is between one and five per 10,000 people who each are exposed to one rem (i.e., a risk coefficient of between 0.0001 and 0.0005). DOE guidance has, in the past, recommended using a risk coefficient of 0.0005 (ICRP, 1991) to estimate risk to a MEOSI. Recent DOE guidance recommends using the even more conservative risk coefficient of 0.0006 provided by the Interagency Steering Committee on Radiation Standards (January 2003). The estimated risk to the hypothetical individual residing near the WVDP from airborne and waterborne releases in 2004 was 3 chances in 100 million (a risk coefficient of 0.00000003). This risk is well below the range of 0.000001 to 0.00001 per year considered by the ICRP in Report Number 26 (1977) to be a reasonable risk for any individual member of the public.

Dose to Biota: Aquatic and Terrestrial Wildlife

Radionuclides from both natural and man-made sources may be found in environmental media such as water, sediments, and soils. In the past, it has been assumed that if radiological controls are sufficient to protect humans, other living things are also likely to be sufficiently protected. This assumption is no longer considered adequate, since populations of plants and animals residing in or near these media or taking food or water from these media may be exposed to a greater extent than are humans. For this reason, the DOE prepared a technical standard which provides methods and guidance to be used to evaluate doses of ionizing radiation to populations of aquatic animals, riparian animals (i.e., those that live along banks of streams or rivers), terrestrial plants, and terrestrial animals.

Methods in this technical standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE-STD-1153-2002, July 2002), were used in 2004 to evaluate radiation doses to aquatic and terrestrial biota within the confines of the WNYNSC, which includes the WVDP. Doses were assessed for compliance with the limit in DOE Order 5400.5 for native aquatic animal organisms (1 rad per day) and for compliance with the thresholds for terrestrial plants (also 1 rad per day) and for terrestrial animals (0.1 rad per day), as proposed in DOE-STD-1153-2002. Note that the absorbed dose unit (rad) is used for biota instead of the units used for indicating human risk (rem).

The RESRAD-BIOTA Code, a calculation tool provided by the DOE for implementing the technical standard, was used to compare existing radionuclide concentration data from environmental sampling with biota concentration guide (BCG) screening values and to estimate upper bounding doses to biota. Data collected from surface waters, sediments, and soils on and around the WNYNSC over a ten-year period (1991–2000) were used as a baseline. For a more near-term assessment, a second evaluation was completed using surface water data from 2004, sediment data from the last five years (2000–2004), and soil data from the last ten years (1995–2004). Differing time periods were used because radionuclide concentrations change more rapidly over time in surface waters than in sediments and soils, as reflected in their sampling frequencies (weekly or monthly for water, annually for sediments and soils). Longer time periods were also required for sediments and soils to obtain sufficient data points to produce

reliable annual averages. (See Appendices A and B[CD] for maps and descriptions of monitoring and surveillance locations. Radionuclides analyzed for each medium at each location are listed in Appendix B[CD]. See Appendices C and G[CD] for a summary of results from these locations in 2004.)

Concentration data for radionuclides in each medium were entered into the RESRAD-BIOTA Code. The value for each radionuclide was automatically divided by its corresponding BCG in order to calculate a partial fraction for each nuclide for each medium. Partial fractions for each medium were added to produce a sum of fractions.

It was found that the isotopes with the highest sums of fractions – the radionuclides that contributed the largest component of both aquatic and terrestrial dose to biota – were strontium-90 and cesium-137. Per guidance in DOE-STD-1153-2002, the populations of organisms most sensitive to strontium-90 and cesium-137 in this evaluation – that is, those populations residing on the WNYNSC that were most likely to be adversely affected via the aquatic and terrestrial pathways – were determined to be populations of the raccoon (aquatic dose) and the deer mouse (terrestrial dose). As such, this study does not pertain to pathways to humans, which were addressed earlier in this chapter.

Exposures from the aquatic pathway may be assumed to be less than the aquatic dose limit from DOE Order 5400.5 if the sum of fractions for the water medium plus that for the sediment medium is less than 1.0. Similarly, exposures from the terrestrial pathway may be assumed to be less than the proposed dose limits for both terrestrial plants and animals if the sum of fractions for the water medium plus that for the soil medium is less than 1.0.

In accordance with the approach described in DOE-STD-1153-2002, a general screening was first conducted using the maximum radionuclide concentrations from surface waters, sediments, and soils. Maximum radionuclide concentrations exceeded applicable general screening BCG limits for both aquatic and terrestrial evaluations.

As recommended in DOE-STD-1153-2002, a site-specific screening was then done using estimates of average radionuclide concentrations derived from measurements in surface waters, sediments, and soils. Results are summarized in Table 2-4.

At the site-specific screening level for the full ten-year period, the sums of fractions for the aquatic and terrestrial system evaluations were 0.45 and 0.57, respectively. The comparable sums of fractions using the more near-term data were 0.17 and 0.31, respectively. The sum of fractions for each assessment was less than 1.0, indicating that applicable BCGs were met for both the aquatic and terrestrial evaluations.

Upper bounding doses associated with the aquatic system evaluation were 0.0059 rad/day to an aquatic animal and 0.017 rad/day to a riparian animal, far below the 1 rad/day standard from DOE Order 5400.5 for dose to a native aquatic animal. Upper bounding doses associated with the terrestrial system evaluation were 0.031 and 0.0027 rad/day to terrestrial animals and plants, again well below the guidance thresholds (0.1 and 1.0 rad/day, respectively).

It was therefore concluded that populations of aquatic and terrestrial biota (both plants and animals) on the WNYNSC are not being exposed to doses in excess of the existing DOE dose standard for native aquatic animals (U.S. DOE, February 1990) and the international standards for terrestrial organisms (International Atomic Energy Agency [IAEA], 1992).

Summary

Predictive computer modeling of airborne and waterborne releases resulted in estimated hypothetical doses to the maximally exposed individual that were orders of magnitude below all applicable EPA standards and DOE Orders, which place limitations on the release of radioactive materials and dose to individual members of the public. The collective population dose was also assessed and found to be orders of magnitude below the natural background radiation dose. Additionally, estimates of dose to biota indicated that biota at the WVDP are exposed at a fraction of the DOE and IAEA guidelines for dose to biota.

Based on the overall dose assessment, the WVDP was found to be in compliance with applicable effluent radiological guidelines and standards during calendar year 2004. Table 2-5 provides a summary of WVDP releases and calculated doses in the specified DOE format.

Table 2-4
2004 Evaluation of Dose to Aquatic and Terrestrial Biota

Aquatic System Evaluation (Near-Term Data Set)

Nuclide	Water BCG* (pCi/L)	Mean Water Value (pCi/L)	Ratio	Sediment BCG* (pCi/g)	Mean Sediment Value (pCi/g)	Ratio	Water and Sediment Sum of Fractions
Cesium-137	42.7	2.98	6.98E-02	3,130	6.43	2.06E-03	0.072
Strontium-90	279	26.9	9.65E-02	583	0.691	1.19E-03	0.10
All Others	NA	NA	7.47E-04	NA	NA	5.31E-04	<0.01
Sum of Fractions (Near-Term Data)			1.67E-01			3.77E-03	**0.17**
Sum of Fractions (Long-Term [10-Yr] Data)			4.47E-01			5.65E-03	**0.45**

Estimated upper bounding dose to an aquatic animal = 0.0059 rad/day; to a riparian animal = 0.017 rad/day.

Terrestrial System Evaluation (Near-Term Data Set)

Nuclide	Water BCG* (pCi/L)	Mean Water Value (pCi/L)	Ratio	Soil BCG* (pCi/g)	Mean Soil Value (pCi/g)	Ratio	Water and Soil Sum of Fractions
Cesium-137	599,000	2.98	4.97E-06	20.8	4.82	2.32E-01	0.23
Strontium-90	54,500	26.9	4.94E-04	22.5	1.70	7.56E-02	0.076
All Others	NA	NA	2.39E-06	NA	NA	7.91E-04	<0.001
Sum of Fractions (Near-Term Data)			5.01E-04			3.08E-01	**0.31**
Sum of Fractions (Long-Term [10-Yr] Data)			7.20E-04			5.66E-01	**0.57**

Estimated upper bounding dose to a terrestrial plant = 0.0027 rad/day; to a terrestrial animal = 0.031 rad/day.

* The biota concentration guides (BCGs) are calculated values. Except for the sums of fractions and dose estimates, which are rounded to two significant digits, all values are expressed to three significant digits.

Table 2-5
WVDP Radiological Dose and Release Summary

WVDP Radiological Dose Reporting Table CY 2004

Dose to the Maximally Exposed Individual		% of DOE 100-mrem Limit	Estimated Population Dose		Population Within 50 Miles *(2000 census)*	Estimated Natural Radiation Population Dose
0.049 *mrem*	0.00049 *(mSv)*	0.049	0.20 *person-rem*	0.0020 *(person-Sv)*	1,536,000	453,000 *person-rem*

WVDP Radiological Atmospheric Emissions[a] CY 2004 in Curies (Bq)

Tritium	Kr-85	Noble Gases ($T_{½}$<40 dy)	Short-Lived Fission and Activation Products ($T_{½}$<3 hr)	Fission and Activation Products ($T_{½}$>3 hr)	Total Radioiodine	Total Radiostrontium	Total Uranium[b]	Total Plutonium	Total Other Actinides	Other (Rn-220)
5.60E-03 (2.07E+08)	NA	NA	NA	5.50E-05 (2.04E+06)	4.22E-05 (1.56E+06)	3.15E-05 (1.17E+06)	2.07E-07 (7.66E+03)	1.58E-06 (5.86E+04)	2.12E-06 (7.84E+04)	1.10E+03 (4.05E+13)

WVDP Liquid Effluent Releases[a] of Radionuclide Material CY 2004 in Curies (Bq)

Tritium	Fission and Activation Products ($T_{½}$>3 hr)	Total Radioiodine	Total Radiostrontium	Total Uranium[c]	Total Plutonium	Total Other Actinides
9.55E-02 (3.54E+09)	7.14E-03 (2.64E+08)	1.78E-04 (6.58E+06)	2.00E-01 (7.39E+09)	1.07E-03 (3.95E+07)	1.63E-05 (6.05E+05)	2.95E-05 (1.09E+06)

NA - Not applicable

[a] The WVDP air and water releases are from point source and controlled liquid effluent releases, respectively.

[b] Total uranium (grams) = 2.10E-01

[c] Total uranium (grams) = 7.86E+02

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